*innovation or adoption?: Renewable POLICIES of OECD countries*

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## Overview

Renewable energy(RE) technologies are essential elements to develop and diffuse for mitigation of climate change. For that reason, large investment has been made on RE technology development and diffusion in all around the world. Furthermore, as conventional energy sources such as fossil fuels are geographically biased, countries with high fossil fuel import dependency could face insecurity in stable fossil fuel supply so that RE technology bears great importance in the aspect of energy security as well.

In electricity sector, two market-pull policies, FIT(Feed-in-tariff) and RPS(Renewable Portfolio Standard), are commonly used policy instruments for promoting RE use in many contries. The former guarantees certain rate of profit to electricity producers no matter what kind of RE source they use, however, the latter does not. Rather, electricity producers can use the most reasonable RE for generation to meet a quota under RPS so that they naturally tend to focus more on improving economic efficiency rather than developing innovative technologies. As a result, two policies may show different level of dynamic efficiency each other, which measures how much the policy encourages technological innovation. Although the primary purpose of introducing those policies is to encourage RE adoption in generation sector, if one policy can affect certain step of innovation(invention, innovation, and diffusion), that is, it has higher dynamic efficiency, we can also expect technological innovation as well as diffusion of RE. Therefore, it would be meaningful to find how much each policy yields RE technology adoption and also promotes innovations, and how much two policies’ effects are different among various RE sources such as wind, solarPV, and geothermal energy.

Recently, not a few papers have dealt with the dynamic efficiency of RE policy. Schmid(2012), Zhao et al.(2013) and Smith & Urpelainen(2014) analyzed the effect of the RE policies on the adoption of RE technologies. On the other hand, Johnstone *et al.*(2010) and Kim(2013) examined the effect of the renewable policies on the innovation of renewable technologies using patent data. Some papers such as Marques and Fuinhas(2011) tried to find the drivers promoting RE. However, at our best knowledge, there is no paper that dealt with FIT and RPS for assessing their dynamic efficiency in the aspects of technological innovation as well as diffusion. In this paper, we analyzed and compared the dynamic efficiency of two policies.

## Methods

Firstly, we analyzed the effect of FIT and RPS on RE technology innovation using patent data, and then the effect of each policy on RE adoption using electricity generated by RE. In the analysis, we take the natural log onto dependent and independent variables except dummy variables, because we wanted to get the elasticity by FIT and RPS. The detailed formulas in reduced form are shown below:

ln(PATit)=β1(FITit)+β2(RPSit)+β3ln(CONSit)+β4ln(PRICEit)+β5ln(RNDSTit)+β6ln(PTOTit)+αi+εit (1)

ln(EGENit)=β1(FITit)+β2(RPSit)+β3ln(CONSit)+β4ln(PRICEit)+β5ln(RNDSTit)+β6ln(PTOTit)+αi+εit (2)

where PATENTSit denotes the number of PCT patent applications for RE of ith country at time t, FITit and RPSit dummy variables for the implementation of each policy at time t in ith country, RNDSTit R&D capital stock using RD&D budget in ith country at time t, CONSit and PRICEit electricity consumption and household price of electricity, respectively, and PTOTit total number of PCT patents application in RE technology field. EGENit denotes the electricity generated by RE. αi captures unobservable country-specific heterogeneity and εit is the error term. To decide whether we use fixed-effect or random-effect mode, Hausman test was used. IEA, OECD, and IMF data have been used for the analysis.

## Results

As a result of the analysis, we found the fact that both FIT and RPS had positive and significant effect on RE technology innovation. However, only RPS showed positive and significant effect on RE deployment so that we can roughly tell that RPS has higher dynamic efficiency than FIT. Secondly, FIT had more impact on technological innovation rather than adoption. In the analysis’ result, RPS showed higher estimates for innovation than for adoption. However, we need to interpret this figure carefully because the difference between the two estimates, FIT and RPS, in Model 2 is larger than that in Model 1. Last but not least, the difference of each policy’s dynamic efficiency among RE sources were examined. For FIT, ther was no big differences among renewable sources for both innovation and adoption. RPS had similar direction and magnitude of effect on the generation by wind and solarPV in the aspect of innovation, though no significant effect on geothermal energy generation. On the other hand, in the aspect of technology adoption, wind and geothermal energy generation had much more impact by RPS while solarPV does not.

## Discussions

According to our analysis, RPS shows higher dynamic efficiency than FIT in both innovation and adoption, even FIT shows no significant impact on RE adoption. However, when we consider about the well-known best practice case for FIT implementation such as Germany and Spain, this result is quite surprising. Although one of the reasons may be due to the fact that RPS well stimulated the demand-side of RE generation, we can cautiously draw the reason of this that in many countries FIT has given not enough or unintended signal or incentives to innovate to generation sector. Therefore, further work in the area would deal with the design elements of both policies and its results will help one country to decide and design policies for RE technology innovation and diffusion.

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